Strategic Implications of Elite Plantation Deployment

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Abstract: After years of development, elite varieties of clonal pine seedlings are becoming commercially available to industrial forestry companies and timberland investment management organizations. Forest managers now must consider the strategic implications of their deployment on their timberland holdings, particularly how deployment and future growth of elite seedlings will impact the management strategy for their timberlands.

Where forests are managed with harvest flow constraints in place (e.g., wood supply agreements), immediate increases in harvest rates can be achieved through intensive forest management that increases growth rates – the so-called "allowable cut effect" (ACE). Deploying fast-growing elite clones should have similar effects. Understanding the magnitude of ACE attributable to elite seedlings, and carefully managing the transition may create important strategic advantages.

We start with a simulated intensively managed southern forest. Estimates of future expected yields are determined using early growth data from currently-available elite loblolly pine clones. A linear-programming forest model is used to determine the optimal base line management strategy (without elite deployment). Next, four alternative elite variety deployment strategies are analyzed and compared to determine their impacts on financial returns and wood flows. All of these alternatives are compared to the base case with no elite deployment. Impacts on wood flow, cash flow, and net present value are determined and presented.

Results show that harvest levels, cash flows and net present values increase in each case. The allowable cut effect provides enough incremental wood flow and cash flow to pay for elite plantation establishment in all cases except the second case, which limits harvest to pre-elite levels. These results show that while stand level elite plantings are NPV positive, strategic forest level planting are even more profitable due to the NPV gains from the ACE.

Keywords: clonal deployment, elite varieties, loblolly pine, modeling, optimization, financial return.

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1 Introduction

After years of development, elite varieties of pine seedlings are becoming commercially available. Seedlings of these elite varieties can be purchased by vertically integrated forest companies, private & governmental institutions, and large & small landowners.

Forest managers and individual owners now must consider the strategic implications of these seedlings' deployment on their timberland holdings. In particular they must consider how the deployment and future growth of elite varieties will affect management strategies. Managers must have information to provide a better understanding of forest level effects of fast-growing elite variety deployment. In order to provide perspective to this decision we evaluate the economic impact and wood flows resulting from an array of deployment strategies in the southeast United States. The analysis provides information about the strategic implications of each deployment strategy and shows how the allowable cut effect will allow us to capture some of the benefits immediately.

Historically, little effort has been made to look at alternative management regimes or ranges of silvicultural intensity beyond those regimes that were currently in practice. The harvest scheduling exercise produced an allowable cut figure and with such averaged input information, it was reasonable that foresters would use the resulting harvest schedule only as a rough guide during implementation.

More complex planning requirements, the availability of highly detailed GIS and inventory systems, and the advent of fast computers and more robust planning tools have led to comprehensive forest plans that go beyond just calculating harvest levels. Forest management plans now involve managing for multiple objectives including wood flow, cash flow, ecological, and wildlife objectives. Far greater detail goes into the models, often employing stand-level inventory and yield information. These models evaluate a large variety of alternatives in selecting the appropriate silvicultural intensity and set of management regimes that maximize present net value or other management objectives.

New alternatives are becoming available which should be investigated in order to understand their implications in the context of a comprehensive forest plan. We investigated four hypothetical deployment methods for elite planting stock and illustrate the optimal forest management plan. The objectives of the study were to:

- Compare these four scenarios to the base case (second generation seedlings)
- Assess the impact on wood flow, cash flow, and net present value for each scenario
- Derive management and policy implications

Elite varieties result from breeding among the best improved trees from traditional tree improvement programs developed in the United States south over the past 50 years. Following testing, elite varieties are selected and mass produced using advanced techniques to create millions of identical individuals for commercial planting. Promising gains in forest value are expected. Elite varieties provide greater yields, shorter rotations, and higher returns than unimproved plantations (Shelbourne, 1997). According to recent studies (unpublished but publicly presented) in loblolly pine, which have reached three generations of tree improvement, MeadWestvaco, International Paper, and CellFor have recorded gains of more than 40% over unimproved loblolly pine seedlings.

Similarly, research has shown that with improved tree breeding along with improved silviculture, growth rates have evolved dramatically. Borders and Bailey (2001) evaluated three forest management scenarios (pessimistic, average, and optimistic respectively), which had projected yields of 20, 23, and 26 ton/ha/year at age 14. They concluded that growth rates of loblolly pine in the Southeast were well below their potential. With their proposed silvicultural regimes and with tested elite varieties, gains in volume have been projected to be as high as 33% over second generation seedlings. Current field data through age 7 confirm this expectation (Wright and Dougherty, 2006). In a similar discussion presented by Stanturf et al (2003), the authors chart five stages of the evolution in the gain in productivity of Southern pine plantations from 2.5 tons/ha/yr to 20 tons/ha/yr between 1920 to 2003.

In addition, elite varieties can be selected for wood quality: specific gravity, microfibril angle, fiber length, juvenile wood characteristics, crown form, and branching habits. According to Hornsby (2006), varietals "illustrated significantly superior wood quality characteristics". The varieties "which illustrated superior growth as compared to controls, also illustrated superior wood quality characteristics with respect to weighted core specific gravity and latewood percentage".

The use of varietals also enhances stand development. Field cruises record higher uniformity, with narrower diameter distributions and less crown stratification. Stand management is also improved with expectations for more predictable yields, higher survival rates leading to lower planting densities, and the ability to thin only for spacing rather than for elimination of poorly formed or slow growing trees. Other advantages include the virtual elimination of fusiform rust and other diseases, lower inventory and harvest costs, and shorter rotation lengths.

The deployment of elite pine varieties present new opportunities for creating value. By creating faster growing forests using elite varieties, an investor can affect profit improvements in a sustainable manner. Current pressures to optimize land use, customize products, and create maximum returns are driving timberland investors to consider these new commercial seedling products, which have been established, to date, on more than 20,000 acres in the United States south.

2 Methods

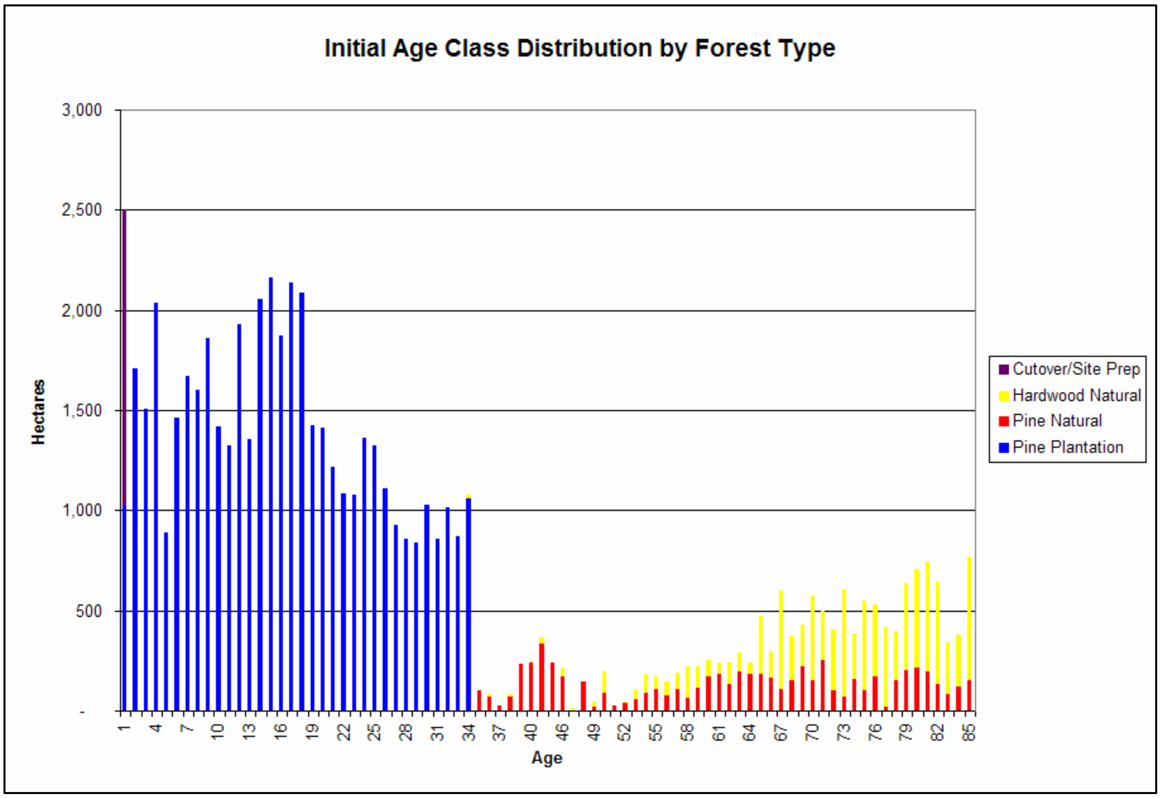
2.1 Forest Dataset

A South Carolina National Forest database served as the foundation for the simulated forest used in this analysis. Significant alterations to the National Forest database, totaling 64,333 hectares in size, were made so that it would better represent a managed industrial forest.

The simulated forest was categorized into 47,549 hectares of pine plantation, 6,377 hectares of natural hardwood, 8,925 hectares of natural pine, 883 hectares of previously site prepared land,

and 599 hectares of cutover stand conditions. A portion of the forest was also categorized as having been thinned, 7,721 hectares or 12% of the total area. Each of the 3,588 forest stands was assigned an age, with the initial age-class distribution (Figure 1) representing conditions common to the industrially managed timberlands in the SE USA.

Figure 1: Initial age-class distribution, by forest type, assigned to the simulated forest.



The simulated forest was categorized into 9 site index classes ranging from 15.2 to 30.5 meters at 25 years. The distribution of site classes by area is detailed in Table 1.

Table 1: Distribution of site class by area.

Site Index (@25 years)	Hectares	% Area
15.2	59	0.1%
18.3	3,100	4.8%
19.8	4,282	6.7%
21.3	24,100	37.5%
22.9	11,240	17.5%
24.4	13,264	20.6%
25.9	4,317	6.7%
27.4	3,110	4.8%

30.5	861	1.3%
Total	**64,333**	100%

Ten categories of trees per hectare (TPH) were assigned, with 49.6% or 31,903 hectares having TPH's equal to or greater than 121. The distribution of TPH by area is detailed in Table 2.

Table 2: Distribution of trees per hectare (TPH) by area.

TPH	Hectares	% Area
<40	13113	20.4%
40-60	3,755	5.8%
61-80	171	0.3%
81-120	15,391	23.9%
121-160	6,340	9.9%
161-200	4,723	7.3%
201-220	2,148	3.3%
221-240	13,768	21.4%
241-280	3,793	5.9%
281+	1,131	1.8%
	64,333	100%

2.2 Growth Modeling

A biometrics analysis divided the simulated forest into 588 strata. These existing strata were then grown using a propriety growth and yield model specific to the Southeast USA. This analysis included growth and yield responses for mid-rotation fertilization with and without thinning.

In order to enable others to review and/or replicate our work, newly established plantations were grown using FASTLOB2, which is a widely available stand-level growth and yield model for simulating the growth of managed loblolly pine plantations (Amateis et al, 2005).

Establishment and early stand silviculture was designed to be similar between the base case and the elite plantation options but with differences to reflect that would be appropriate for good establishment and growth of the subsequent stands. As such planting was assumed to be at 1483 trees per hectare with 90 percent survival (1334 survivors) for second generation planting stock, and 1235 trees per hectare with 95 percent survival (1174 survivors) for the elite planting stock. Both types of plantation received an herbaceous weed control at age one. Both types had the option of receiving a fertilization treatment at age seven.

Newly established regeneration strata which are created via transitions after final harvest of existing strata in the Woodstock model were aggregated into one of three site index classes. For these strata, which are created in future periods of the model, adjustments were made to site index in order to account for differences in growth between second generation planting stock and elite varieties planted in clonal block plantings. There is considerable uncertainty about future yields of these elite varieties since newly established tests of these elite varieties are only in their seventh growing season. In the absence of definitive future yield projections, assumptions must be made to account for expected increases in volumes when planting elite varieties. An adjustment was made in the form of a site index adjustment. This site index adjustment was approximately 25% increase in site indices as shown in Table 3. When similar silvicultural regimes are applied, this site index adjustment generates approximately 42 percent more volume than unimproved seedlings when thinning volume and final harvest volumes are considered. While the various commercially available elite varieties have different growth characteristics, the assumptions made here are within expectations for commercially available elite planting stock. It will require several more years of cruise data before final harvest yields can be predicted with some level of certainty. While additional advantages exist from the planting of elite varieties, the only adjustment made in this analysis is the adjustment to growth rates via the increases in base site index.

Table 3: Site index base age 25 for second generation and elite variety regenerated plantations.

Regeneration Strata	Second Generation Site Index$_{25}$ (m)	Elite Variety Site Index$_{25}$ (m)
Low	18.3	22.9
Medium	19.8	24.7
High	21.3	26.5

Products merchandised for this analysis included pine pulpwood, pine topwood, pine chip ‘n’ saw, pine sawtimber, hardwood pulpwood, and hardwood sawtimber. The starting inventory for this analysis is detailed in Table 4. On average the volume of pine stands was 77.9 tonnes/hectare and the volume of hardwood stands was 129.6 tonnes/hectare.

Table 4: Starting inventory of the simulated forest (metric tonnes).

Product	Volume (tonnes)
Pine Pulpwood	3,065,872
Pine Topwood	104,771
Pine Chip ‘n’ saw	3,561,960
Pine Sawtimber	3,649,137
Pine Sub-Total	**10,381,740**
Hardwood Pulpwood	830,459
Hardwood Sawtimber	2,027,359
Hardwood Sub-Total	**2,857,818**
Pine + Hardwood Total	**13,239,558**

2.3 Strategic Model

A strategic model was formulated utilizing *WOODSTOCK™,* which is part of the Remsoft Spatial Planning System, employing Model-II linear-programming optimization techniques (Remsoft 2006). This strategic planning model included a number of assumptions, including:

1. Only even-aged forest management was employed.
2. Silviculture included site preparation, plantation establishment, maintenance, and fertilization.
3. Harvesting included thinning (optional) and final harvest (clearcut).
4. All thinning operations received a post thinning fertilization application. Both second generation plantations and elite plantations were given a four year window of thinning opportunities. Thinning was permitted between the ages of 13 and 16 for second generation plantations and between 10 and 13 for elite plantations. Residual basal area after thinning was 17.2 square meters/hectare (75 square feet/acre).
5. Final harvest was permitted on stands 20 years of age and older for second generation plantations and on stands 16 years of age and older for elite plantations.
6. An 8% real discount rate was used for financial analysis (net of inflation).
7. Financial modeling was all done pre-tax.
8. An objective function maximized NPV over a 100-year model horizon, with 1-year period intervals. Only the first 50-years of the planning horizon were used for reporting, with longer planning horizons used in the model to eliminate artifacts due to "end of planning horizon effects" that are common to all planning models.
9. A sequential flow constraint (+/- 20%) was placed on the pine volume (top wood, pulpwood, Chip 'n' Saw, and saw timber) harvested. The amount of pine harvested could increase or decrease by as much as 20% from one period (year) to another. This reduces wild fluctuations in volume flow over time.
10. A sequential flow constraint (+/- 20%) for acreage 30 years or greater cut in years 1 to 8. The amount of final harvest acres could increase or decrease by as much as 20% from one period (year) to another. This forces the large amount of older natural stands to be cut over time rather than all at once at the start of the model.

Table 5: Timber pricing used in the model.

Timber Mart-South Q2-2006 Southwide Pricing

	$/ton	$/tonne
Pine Sawtimber	$ 37.70	$ 34.20
Pine Chip-n-Saw	$ 22.51	$ 20.42
Pine Pulpwood	$ 6.24	$ 5.66
Hardwood Sawtimber	$ 21.22	$ 19.25
Hardwood Pulpwood	$ 5.40	$ 4.90

Silviculture costs were obtained from publicly available sources (e.g. Forest Landowner, Texas Forest Service) except for the cost of planting stock which was assumed to be $0.05/seedling for second generation planting stock and $0.30/seedling for elite planting stock. With the differences in required planting density (1482 trees per hectare for second generation stock, and 1235 trees per hectare for elite varieties), this leads to a planting stock cost differential of $296 per hectare ($120/acre).

2.4 Alternative Deployment Strategies

Four alternative models were developed to represent different options for elite plantation deployment. These alternatives quantify the advantages of planting this elite material and the trade-offs of the various deployment strategies. Each alternative model is described below, including the deployment strategy that it represents.

2.4.0 Base Model – No Elite Planting

This model alternative is the Base model used for comparison purposes. All model components described above are implemented, but the model is constrained to disallow the planting of elite material. Thus the entire model is based on planting of second generation planting material for which growth and yield estimates are more certain.

2.4.1 Alternative 1 – Optimal Elite Planting

This model alternative allows the planting of elite material. The amount planted is selected by the model to provide the highest net present value. This is the most aggressive and risky of the alternatives because growth projections are based on early data, but it has the highest potential economic return.

2.4.2 Alternative 2 – Same Planting Area and Pine Harvest Volume

This model alternative involved two modeling steps. First, the Base model was solved but constrained to not allow planting of elite material at any time during the model horizon. The planting area and pine harvest volume from this constrained Base model were then used as constraints in Alternative 2, however planting of elite material was allowed if it was the optimal choice. Thus, the harvest and planting levels implemented are from a model known to be sustainable. Any incremental volume from the planting of elite material is available but only after that elite material reaches rotation age and final harvest volume is known with certainty. Since operational elite varieties have only been available for a short time, projections of final harvest volumes are uncertain. This alternative takes a conservative, wait and see, approach by holding off on harvest increases until there is more certainty about final harvest volumes.

2.4.3 Alternative 3 – Ramp up Elite Planting Area

This model alternative restricted planting of elite material. It assumes that elite planting stock is in short supply but will increase in availability over time. It is assumed that the number of seedlings available in years one through five is 1.0 million, 1.5 million, 2.0 million, 2.5 million, and 3.0 million respectively. The effect is to limit the number of hectares of elite plantations that may be established over the first five years. After year five elite planting stock is no longer in short supply so the optimal amount may be planted.

2.4.4 Alternative 4 – Ramp up Planting Proportions

This model alternative also restricts the planting of elite material. However this alternative limits the proportion of acres that may be planted to elite material over time. In the first year only 10% of the plantations established may be planted with elite planting stock. This increases from the second year through the fifth year to 20%, 30%, 40% and 50% respectively. After year five planting continues to be restricted to 50% of the plantations in any one year. This is meant to simulate one potential risk reduction strategy. By mixing elite plantations with traditional plantations risks may be reduced. These risks may be due to catastrophic mortality, or market risks that may exist since mills may not want this fast grown raw material.

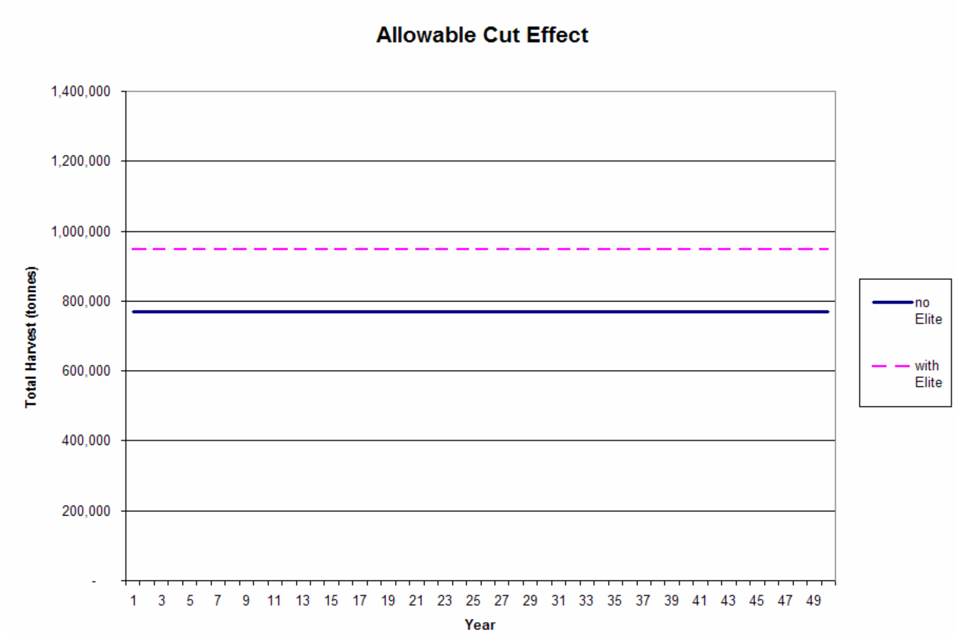
3 Results and Discussion

3.1 Allowable Cut Effect

The so called "Allowable Cut Effect" was much discussed as the silviculture intensity increased in the 1970's and early 1980's. "ACE is the immediate increase in today's allowable cut which is attributable to expected future increases in yields" (Schweitzer et al 1972). Fight and Schweitzer (1974) indicated that allowable cut responds more dramatically when there is a) high initial inventory, b) well distributed age classes, c) growth increases that can be cut sooner, and d) growth increases that are not too large. Many of these conditions, which were in place in the 1970's, are also in place as the forest industry transitions to the much higher growth rates attributable to elite planting material.

In order to understand the magnitude of the potential allowable cut effect, we analyze the impact on allowable cut of the planting of elite planting material on this specific hypothetical forest. In a manner similar to Schweitzer et al (1972), this analysis assumes strict even flow constraints are imposed on both the base yields and the yields with increased growth rates. Figure 2 shows the improvement in harvest levels attributable to the elite plantation deployment allowable cut effect. The allowable cut effect increases pine harvest volumes by 23 percent over the base case. Of significant importance a large proportion of the increase in volume harvested is in the form of the more valuable chip-n-saw products, especially over the 50-year time horizon.

Figure 2. Allowable cut effect due to elite plantation deployment.



Of particular importance in the magnitude of the allowable cut effect are the properties of this specific hypothetical forest and the growth characteristics of the elite material. This analysis combines several of the attributes identified by Fight and Schweitzer (1974). In particular, the forest contains a high initial inventory as shown in Table 4, including significant volumes in the age classes eligible for immediate harvest (Figure 1). It also shows a fairly evenly distributed age class distribution, especially for pine (Figure 1). And finally, the elite varieties studied include a substantial increase in growth rate, with harvests both allowed and expected to be cut earlier.

Table 6: Allowable cut effect due to elite plantation deployment.

Average Annual Pine Harvest Volumes Years 1..20

tonnes	no Elite	with Elite	Difference
Pine Sawtimber	**348,870**	**371,503**	**6%**
Pine ChipnSaw	**223,704**	**296,675**	**33%**
Pine Pulpwood	**196,599**	**279,078**	**42%**
Total	**769,174**	**947,257**	**23%**

Average Annual Pine Harvest Volumes Years 1..50

tonnes	no Elite	with Elite	Difference
Pine Sawtimber	**341,181**	**366,590**	**7%**
Pine ChipnSaw	**173,989**	**247,855**	**42%**
Pine Pulpwood	**254,005**	**332,811**	**31%**
Total	**769,174**	**947,257**	**23%**

3.2 Alternative Cases

3.2.1 Alternative Cases – Impact on Harvest Volume

Harvest volumes over 50 years for the Base model and the four alternative deployment strategies are illustrated in Figure 3. Variations in harvest volume are evident when comparing the four alternative models to the Base model. Case 1, the Optimal Elite case, shows the earliest increase in harvest volume. Case 2, which keeps harvest and planting levels identical to the Base case, shows the longest delay before increasing harvest volume, but shows the highest peak as the built up volume from elite plantations gets harvested. The other two cases fall in the middle with Case 3, which eventually allows unlimited elite plantation acres, intuitively showing earlier harvest volume increases.

Figure 3: 50-Year harvest volumes for the Base case and four alternative deployment strategies

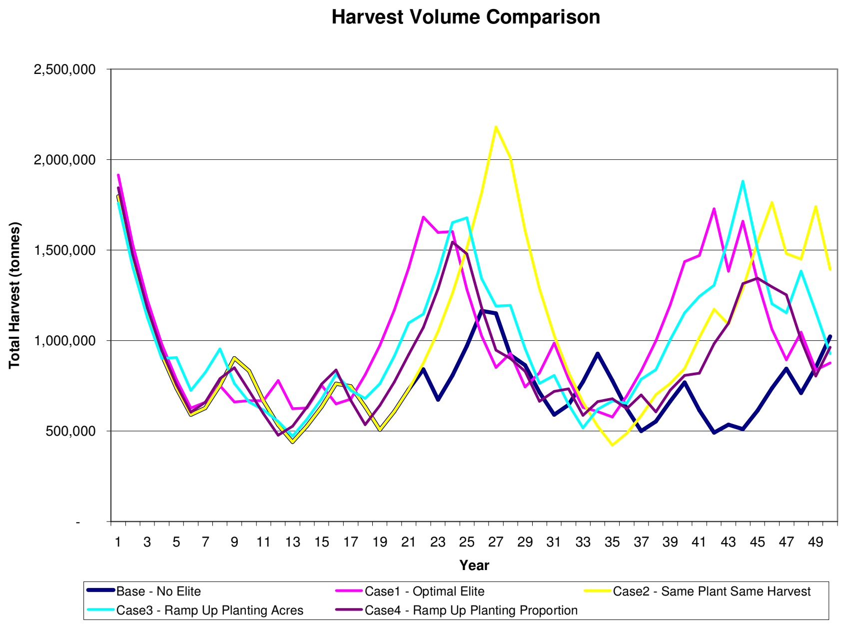


Table 7 shows harvest volume summaries over the first 20 years and the first 50 years. This harvest volume includes volumes from thinning as well as final harvest. Importantly it includes harvest volume from both newly regenerated stands, and from existing stands, from which the allowable cut effect of volume is derived.

Table 7: Harvest volume comparison.

Average Annual Pine Harvest Volumes Years 1..20

Tonnes	Base	Case1	Case2	Case3	Case4
Pine Sawtimber	315,124	331,933	309,423	321,242	319,621
Pine ChipnSaw	229,559	258,074	223,289	245,679	237,409
Pine Pulpwood	245,649	286,246	257,620	273,174	256,549
Total	790,332	876,253	790,332	840,094	813,579

Average Annual Pine Harvest Volumes Years 1..50

Tonnes	Base	Case1	Case2	Case3	Case4
Pine Sawtimber	308,271	384,623	421,940	383,707	340,003
Pine ChipnSaw	180,590	263,425	248,254	262,095	229,845
Pine Pulpwood	278,921	361,694	348,138	358,589	326,340
Total	767,783	1,009,742	1,018,332	1,004,391	896,188

In Case 1, the Optimal Elite Planting case the harvest volume over the first 20 years is 10.9 percent higher than the Base case. This volume increase is attributable to the allowable cut effect. Over the first 50 years this harvest volume increase totals 31.5 percent. In Case 2, the case that forces the Same Planting and Pine Harvest for the first 20 years, the harvest volume is identical for the first 20 years of course. However, over the first 50 years the harvest increases a total of 32.6% over the Base case, which is even higher than the Optimal Elite Planting case. In Case 3, which Ramps up Elite Planting Acres, harvest volume is 30.8 percent higher than the Base case over the first 50 years. This is only slightly below the harvest level shown in the Optimal Elite Planting case which shows that the delay in ramping up the planting of elite material does not materially affect strategic plans as long as the shortage of elite planting material does not last too long. Conversely, the final case, Case 4 which Ramps up Planting Proportions shows only a 16.7 percent increase in harvest volume over the first 50 years. This shows that a permanent limit to the amount of elite plantation deployment, whether as an intentional risk reduction strategy, due to planting stock shortages, or other reasons, can significantly impact future harvest volumes.

3.2.2 Alternative Cases – Impact on Net Cash Flow

Table 8 shows comparisons of pre-tax net cash flow between the Base case and the four alternative deployment strategies over both a 20 year and 50 year time horizon.

Table 8: Net revenue comparison.

Total & Per Hectare Net Revenues Years 1..20

	Base	Case1	Case2	Case3	**Case4**
NetRev (millions)	**$359**	$376	$341	$363	**$362**
NetRev/Hectare	**$5,579**	$5,848	$5,303	$5,639	**$5,621**
Percent Difference		4.8%	-5.0%	1.1%	**0.8%**

Total & Per Hectare Net Revenues Years 1..50

	Base	Case1	Case2	Case3	**Case4**
NetRev (millions)	**$830**	$1,059	$1,123	$1,058	**$943**
NetRev/Hectare	**$12,897**	$16,466	$17,451	$16,444	**$14,653**
Percent Difference		27.7%	35.3%	27.5%	**13.6%**

The first case, Optimal Elite Planting, shows a 4.8 percent increase in net cash flow over the first 20 years. This is an important finding since it shows that the increased revenues due to the allowable cut effect more than offset the increased silvicultural cost due to planting of elite varieties. Over the first 50 years this case shows a total net revenue increase of 27.7 percent. Obviously, the second case, which restricts harvest levels to the levels of the Base case, does not see these increased revenues from allowable cut effects in the first 20 years. The optimal regime selected by the model is still to plant 100% of the new plantations with elite varieties. The increased cost of planting elite varieties leads to a reduction of 5.0 percent in net revenues as we are paying for elite planting stock, but harvesting at Base case level. However, the net revenues rise sharply after this and achieve a 35.3 percent increase over the whole 50 year horizon. Case 3 and Case 4 show minor increases in net cash flow over the first 20 years at 1.1 percent and 0.8 percent respectively. It is important to note that in both of these cases the increased revenues more than cover the cost of elite plantation deployment. Over the 50 year horizon the third case, which restricts planting for only the first five years, shows a 27.5 percent increase in net revenues – only 0.2 percent below the optimal case. This indicates that the cash flow penalty for a slower ramp up of elite plantation deployment is not substantial. Conversely, Case 4 shows only a 13.6 percent increase in net revenues, showing that the permanent limits on planting elite material has a substantial impact the net revenue generation over the 50 year horizon.

3.2.2 Alternative Cases – Impact on Net Present Value

Table 9 shows the net present value of pre-tax cash flows for the Base case and the four alternative cases over both a 20 year and 50 year time period.

Table 9: Net present value comparison.

Total & Per Hectare NPV Years 1..20

	Base	Case1	Case2	Case3	**Case4**
NPV (millions)	**$214**	$216	$205	$214	**$214**
NPV/Hectare	**$1,348**	$1,362	$1,291	$1,345	**$1,348**
Percent Difference		1.1%	-4.2%	-0.2%	**0.1%**

Total & Per Hectare NPV Years 1..50

	Base	Case1	Case2	Case3	**Case4**
NPV (millions)	**$256**	$275	$272	$272	**$265**
NPV/Hectare	**$1,610**	$1,732	$1,711	$1,710	**$1,664**
Percent Difference		7.6%	6.2%	6.2%	**3.4%**

The first case, Optimal Elite Planting, shows a 1.1 percent increase in net present value over the first 20 years. This is lower than the increase in net revenue due to having to pay for the elite planting material up front, but it does show that even on a net present value basis the planting of elite planting stock pays for itself due to the allowable cut effect. The third and fourth cases show about break even on a net present value basis with a 0.2 percent decrease and a 0.1 percent increase respectively. So, these cases both come within three dollars per hectare of paying for the planting of elite material. The second case, which does not allow allowable cut effect harvests shows a 4.2 percent decrease in net present value over the first 20 years since we are paying up front for elite planting stock but harvesting at the Base case level for these 20 years.

Over the 50 year period all four cases show an increase in net present value. The Optimal Elite case shows the largest increase at 7.6 percent. Case 2, which keeps harvest and planting levels the same as the base case for the first 20 years, recovers nicely over the subsequent 30 years so that the impact of delayed ACE harvest on net present value is mostly eliminated over the 50 years (6.2 percent increase versus 7.6 percent increase for Optimal Elite). Case 3, with the slower ramp up of elite planting, also shows a 6.2 percent increase in net present value. The final case, which ramps up planting proportion and permanently limits planting to 50 percent of the planted area, shows a 3.4 increase in net present value. This deployment strategy loses over half of the potential increase of implementing an elite plantation forest. However, this case still generates an increase in net present value, and possibly at a lower risk.

In summary, there were significant gains in harvest volumes, net cash flow, and net present value for all cases allowing elite planting. Adopting the wait and see approach, by limiting harvest levels to those known to be sustainable for the Base case impacts volume, cash flow and net present value over the first 20 years but it is mostly recoverable. The most significant impact to long term harvest volume, cash flow and net present value was the permanent restriction of planting to 50 percent of the area planted. This reduced net present value gains to less than 50 percent of the optimal case but still showed a significant improvement over the Base case with no elite plantations.

4 Conclusions

This analysis attempts to demonstrate the trade offs of alternative elite plantation deployment strategies in a strategic planning model environment. Previous studies have shown that planting of elite material in clonal block plantings can lead to improved financial performance (McKeand et al, 2006). This analysis has shown that by capturing the substantial allowable cut effect financial performance can be enhanced even further. Assuming early projections are correct the deployment of elite plantations will lead to increases in harvest volume flows, and net present value. In addition, the incremental silvicultural cost to pay for the elite planting stock can be more than paid for from the increased revenues from harvest volumes attributable to the allowable cut effect.

Operational scale elite planting has been feasible since 2004 and these plantings have been expanding rapidly in the southern United States. Additional inventory data for these elite varieties is now becoming available which is providing evidence of the potential for increased yields, product improvements, and increased financial returns.

While operational scale planting is recommended for most forest managers due to the substantial financial gains possible in specific markets, further research is required. We must continue research to understand the dynamics of elite plantations including growth rates, genetics by environment interactions, and silvicultural responses of selected elite varieties. In addition, a further understanding of the impacts on reductions in disease and mortality, and improvements in stem form is needed. There are potential improvements in processing efficiencies and harvesting costs due to improvements in uniformity due to tighter diameter distributions which must be understood more fully. Finally, disease, mortality, and diameter distribution changes all have implications on growth and yield modeling and further research is needed here to ensure appropriate modeling of selected elite varieties.

Understanding the growth dynamics of elite plantations is only one part of the equation. Forest planners must also understand the risks of plantation deployment and assist managers in assessing risk and the risk/reward trade-off. Alternative deployment strategies should be considered and analyzed in order to develop appropriate risk mitigation strategies. Since uncertainty exists in deploying these elite varieties, an adaptive management strategy is suggested. In this way, models and plans can adapt to the new information as our scientific understanding of these factors improves.

A key factor in creating significant value is the proper deployment of elite varieties. The substantial allowable cut effect due to large increases in growth rates, and the shortening of the rotation, provides substantial incentives to accelerate elite plantation deployment. This can be seen to be a powerful means of enhancing returns of the US forest industry and allowing it to compete with the southern hemisphere. It is through continued technological improvements, including deployment of elite pine varieties that the United States can compete in the global marketplace.

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